Performance Profiling with AMD GPU Tools: A Case Study

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Agenda

AMD
Smarter Choice

- Introduction
- Motivation
- Introduction to AMD GPUs Tools
- Preconditions for profiling the GPU load of a game
- Case Study: Blue Bytes “The Settlers – 6” (working title)
- Conclusions
- Questions and Answers

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Introduction

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- GPU bottlenecks are non-trivial to understand
  - All understanding derived from observations
  - And could be wrong
  - Even experienced developers can get it wrong ☺
- To rectify this AMD introduced two new GPU tools
  - GPU PerfStudio
    - Real-time performance monitoring
  - GPU ShaderAnalyzer
    - Accurate performance estimates for shaders
- Both tools are DX9 only at the moment
  - The tools talk did demo DX10 and OpenGL versions

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Motivation

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- Show that AMD GPU tools are useful
  - They can be used on real games
  - They deliver insights that are hard to get otherwise
  - Case study: Blue Bytes ‚The Settlers 6' (working title)
- Hope to get you use the tools
  - Try them out
  - Take advantage of their features
  - Give us feedback – we want to improve our tools

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Introduction to AMDs GPU tools

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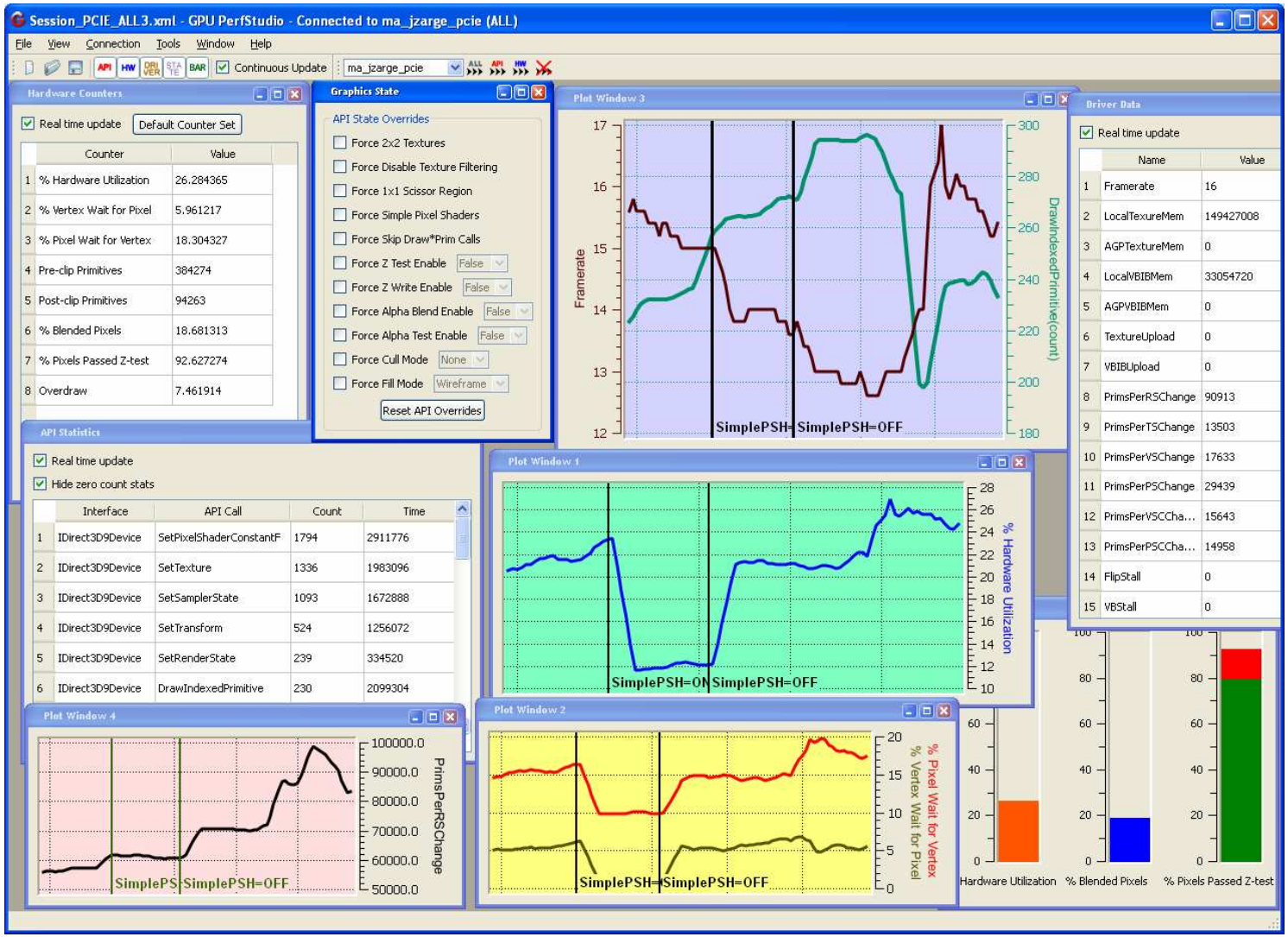
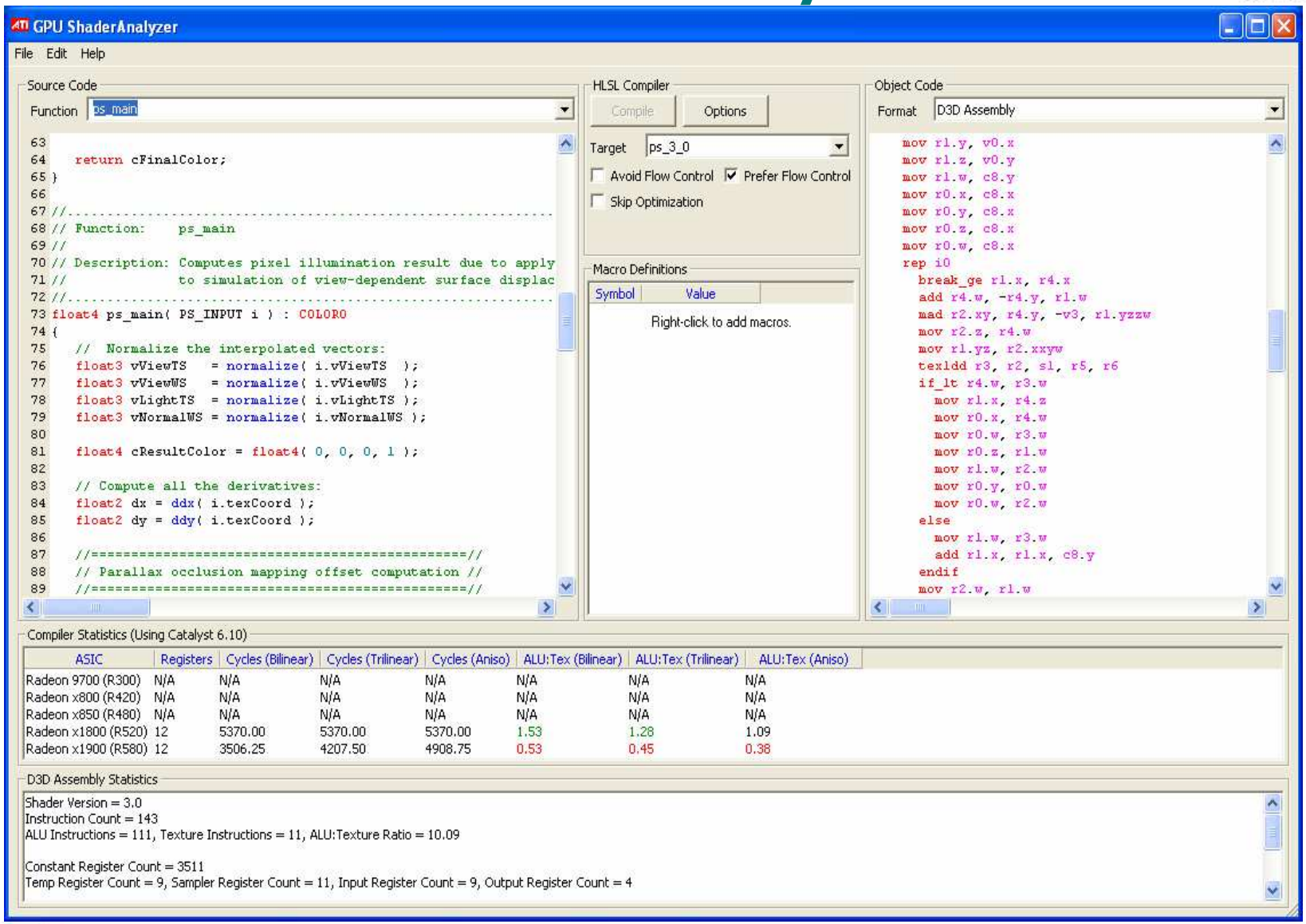
- GPU PerfStudio – real-time view window to the GPU
  - GPU hardware counters
  - Driver Data
  - API statistics
  - Graphics state overrides
  - Client/Server model
- GPU ShaderAnalyzer
  - Accurate performance estimates for shaders
  - Tells you about ALU:TEX
  - Lets you see the hardware shader
  - GUI and command line mode

Screenshot GPU PerfStudio



Screenshot GPU ShaderAnalyzer



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Preconditions for profiling the GPU load of a game

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- Make sure game logic is not in your way
  - Disable AI, physics … the full simulation
- Profiling a full frame does not tell you all
  - Different techniques/passes have different bottlenecks
  - Need to be able to switch on/off selectively

Also:

- Start profiling early
  - Learn bad news early
  - Always be aware of impact of new code

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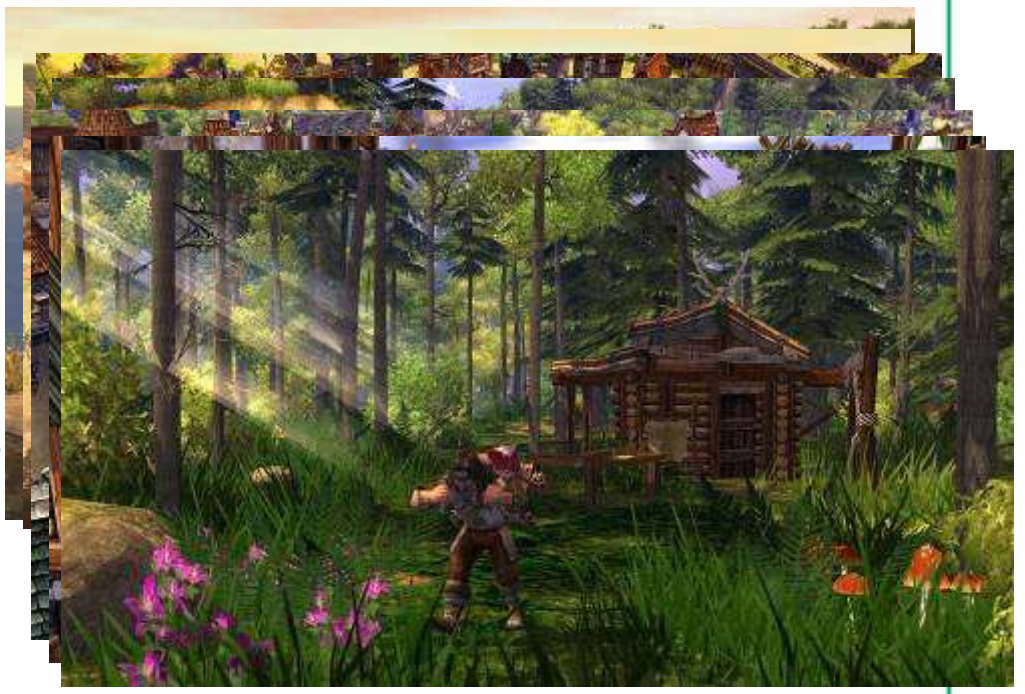
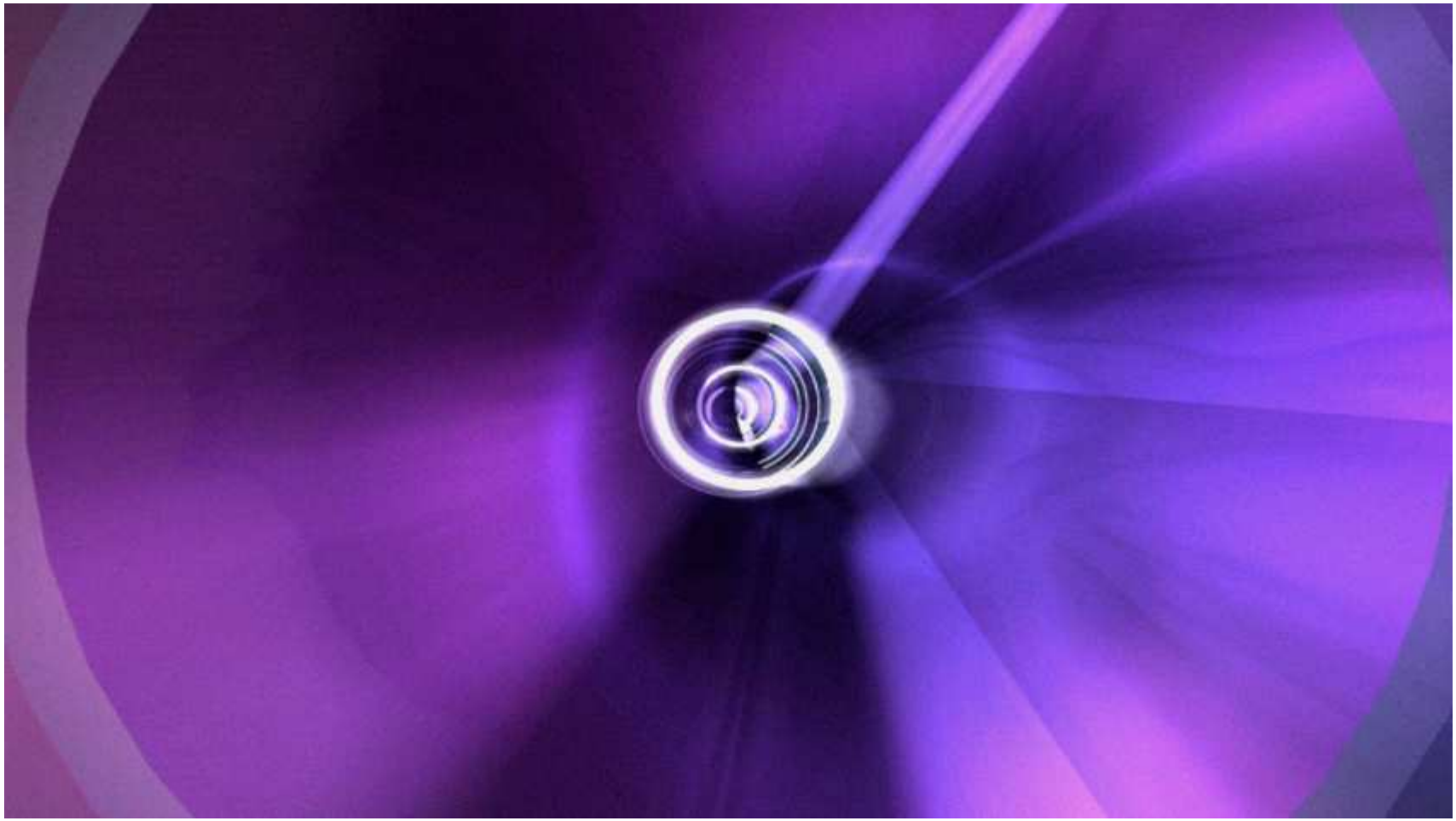
Case Study: Settlers 6 (working title)

- Developer is BlueByte
  - Development started spring ´05
  - Will be released this summer
- Empire building RTS game
  - Set in a medieval world
  - Has a focus on city building
  - Warfare part of the game
- Single & Multi player modes
  - Various multi player modes
  - Story based and free-play maps
- Complex graphics engine
  - Highly dynamic world
  - Lots of foliage



The Settlers®

Case Study: Settlers 6 (working title)



The Settlers®

Decision to use the tools was easy

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- Tools are not invasive
  - No changes to your source code
  - No additional risk even late during a project
  - No additional Q&A ☺
- Tools would allow most efficient way to …
  - Assess impact of rendering techniques for new scene elements
  - Only one scene element covered by this talk

Initial Situation

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- Graphics engine was already very mature
  - Well optimized
  - Deals with highly dynamic landscapes
  - Existing support for enabling/disabling scene elements ☺
- Additional small scene elements were about to be added
  - More grass
  - Flowers, Pebbles, Toadstools etc.
- We will talk about rendering flowers
  - Representative for all small scene details listed above

Initial implementation of Flowers

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- Requirements:
  - Batches of flowers small enough to adapt to terrain
  - Don’t want to render just one flower in a draw call
- Implementation:
  - render a bunch of flowers per draw call
  - It is known that the VS is relatively expensive
    - Scattering is done inside VS
- Let’s use GPU PerfStudio to look at that implementation

Before we really start…

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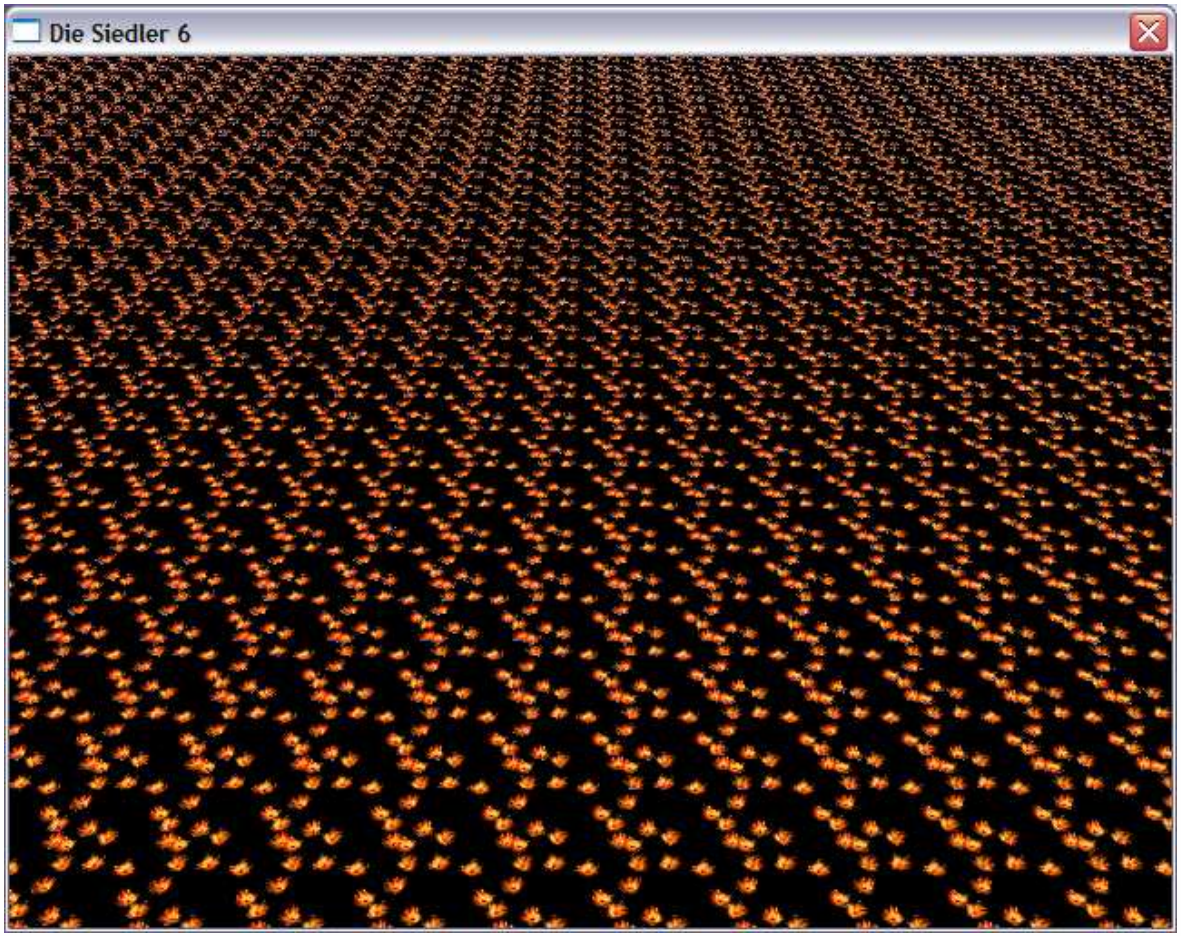
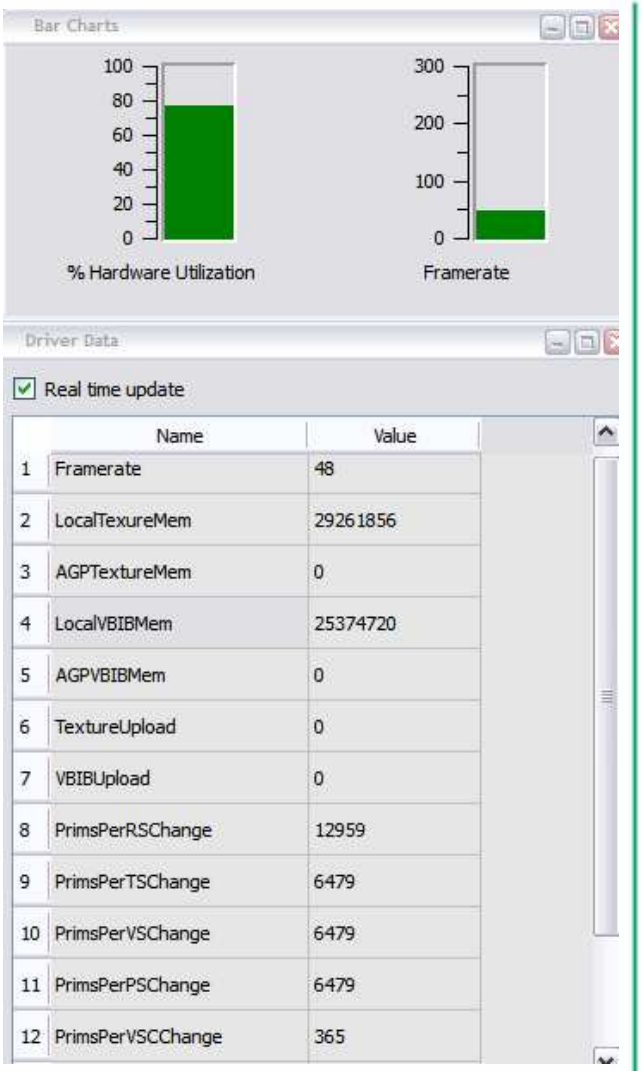
- Talk has been created around results on this machine
  - X1300 laptop accelerator
  - Results will vary on desktop cards or other laptops
  - Will pretend that this laptop is a constant target platform
    - With constant resolution, memory bandwidth etc.
- Wanted results that can be repeated during the talk
- Won't talk about every feature of the tools
- Concentrate on easy to understand measurements
- Case study is about a DX9 title
  - supposed to run on DX9 hardware
  - Not on unified shader hardware

Let's run GPU PerfStudio …

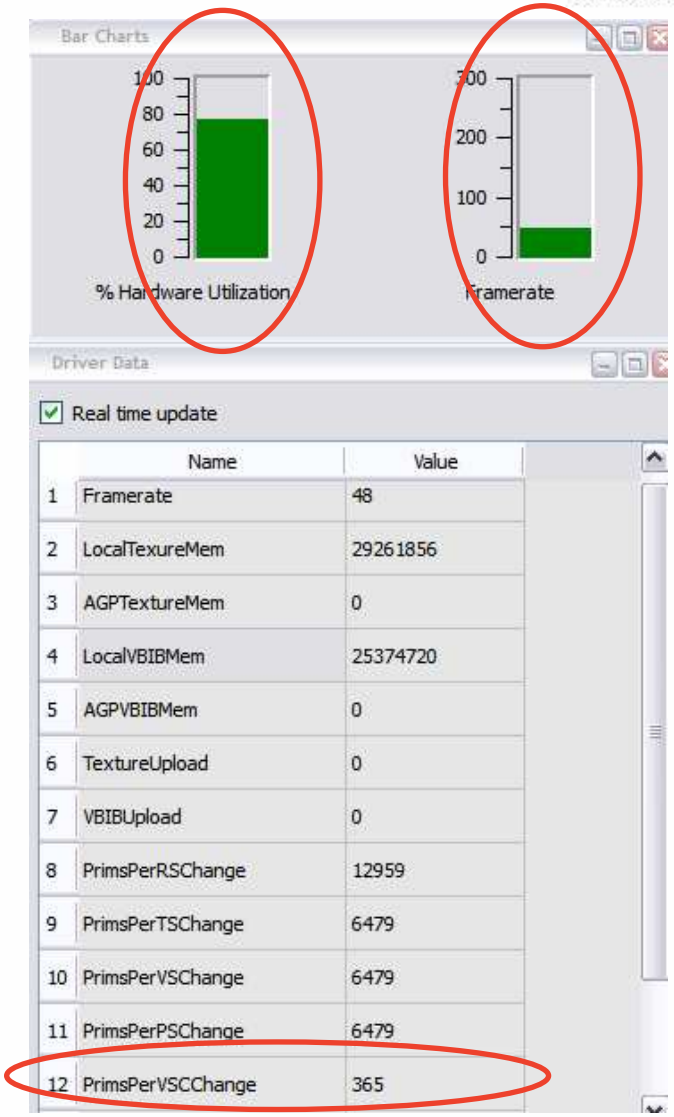




	Name	Value
1	Framerate	48
2	LocalTexureMem	29261856
3	AGPTextureMem	0
4	LocalVBIBMem	25374720
5	AGPVBIBMem	0
6	TextureUpload	0
7	VBIBUpload	0
8	PrimsPerRSChange	12959
9	PrimsPerTSChange	6479
10	PrimsPerVSChange	6479
11	PrimsPerPSChange	6479
12	PrimsPerVSCChange	365

Results - Flowers

- Hardware utilization not bad
- FPS ~50 … not too good
- But we want to maximize FPS
  - And we can do better !
- PrimsPerVSCChange is low !



Improving the performance

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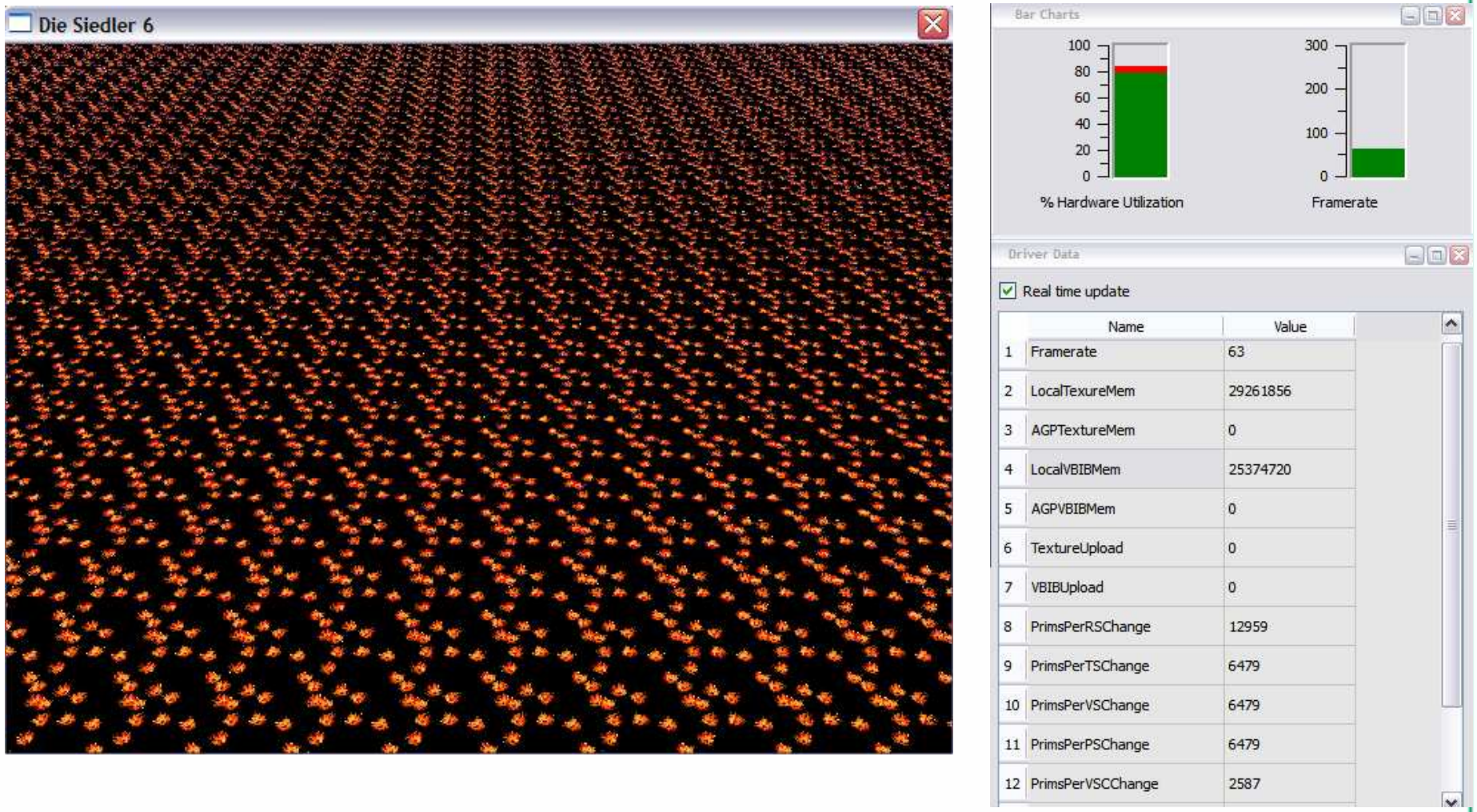
- We'll use instancing to increase PrimsPerVSCChange
- Our options are:
  - Hardware instancing
  - Shader constants instancing
- Shader constants instancing used for max compatibility
- VertexBuffer contains several copies of geometry
- Vertices contain index to constants array of positions
- Now we can draw several batches of flowers at once

Let's run GPU PerfStudio again …



	Name	Value
1	Framerate	63
2	LocalTexureMem	29261856
3	AGPTextureMem	0
4	LocalVBIBMem	25374720
5	AGPVBIBMem	0
6	TextureUpload	0
7	VBIBUpload	0
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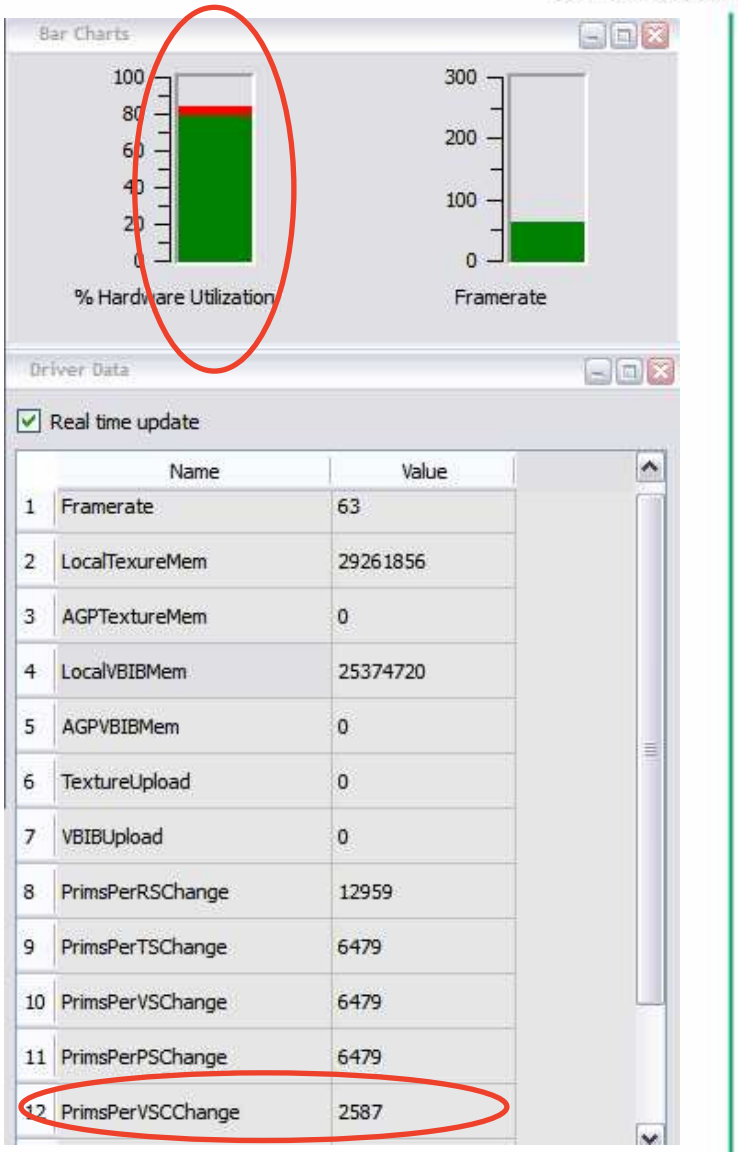
10	PrimsPerVSChange	6479
11	PrimsPerPSChange	6479
12	PrimsPerVSCChange	2587

Improved Results – Instanced Flowers

- Hardware better now
- PrimsPerVSCChange went up a lot
- Fps ~60 !
- We are happy now ! ☺
- Can do even better ?



	Name	Value
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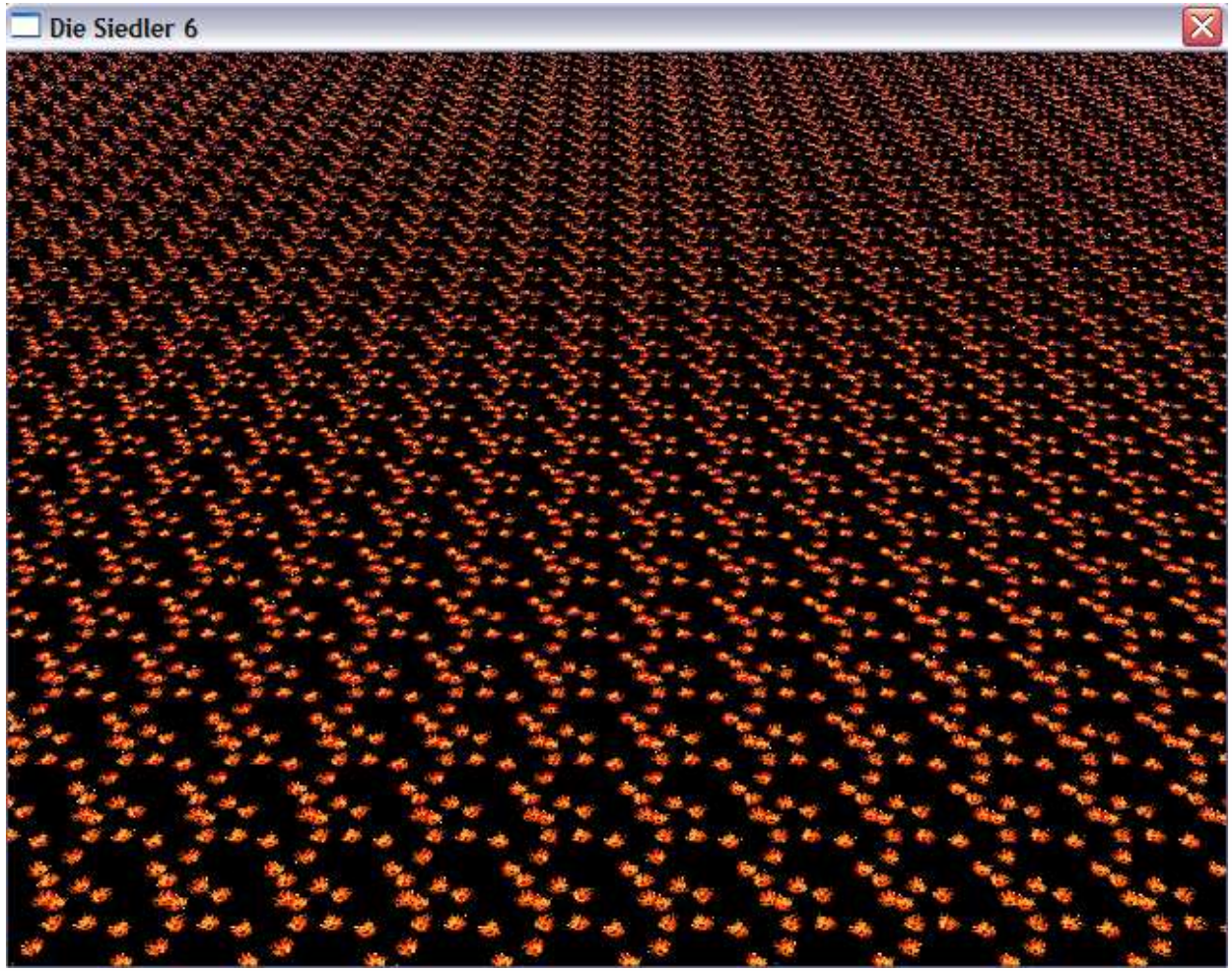
Let's run GPU PerfStudio again …



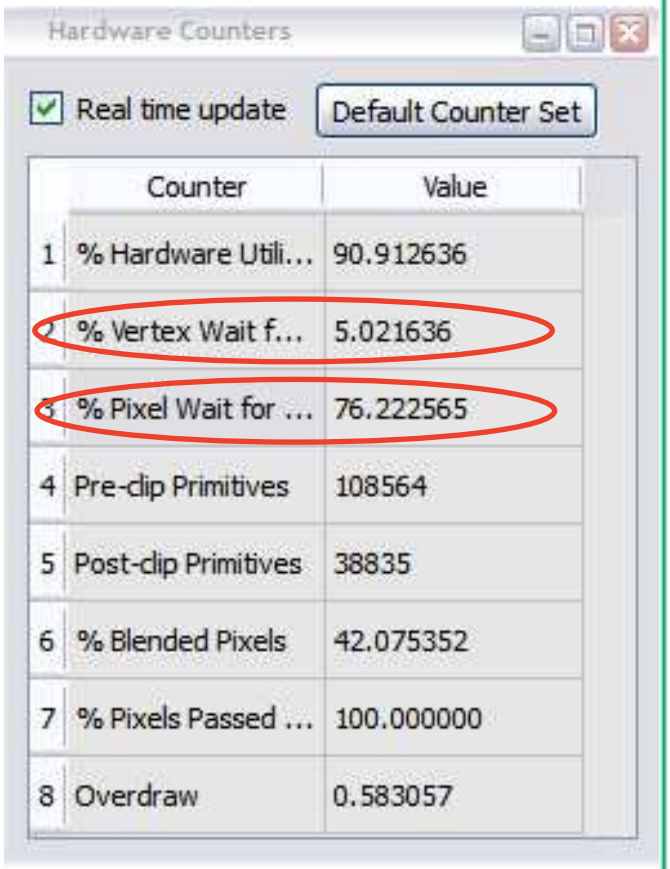
Hardware Counters

Real time update | Default Counter Set

	Counter	Value
1	% Hardware Utili…	90.912636
2	% Vertex Wait f…	5.021636
3	% Pixel Wait for …	76.222565
4	Pre-clip Primitives	108564
5	Post-clip Primitives	38835
6	% Blended Pixels	42.075352
7	% Pixels Passed …	100.000000
8	Overdraw	0.583057

What else is not optimal ?

- Let's look at vertex vs. pixel loads
- % Vertex wf Pixel ~5
- % Pixel wf Vertex ~75
- This indicates a vertex limitation
  - We know it is not vertex locality!
  - Vertex locality has been optimized



How can we still improve our frame rate on this machine?

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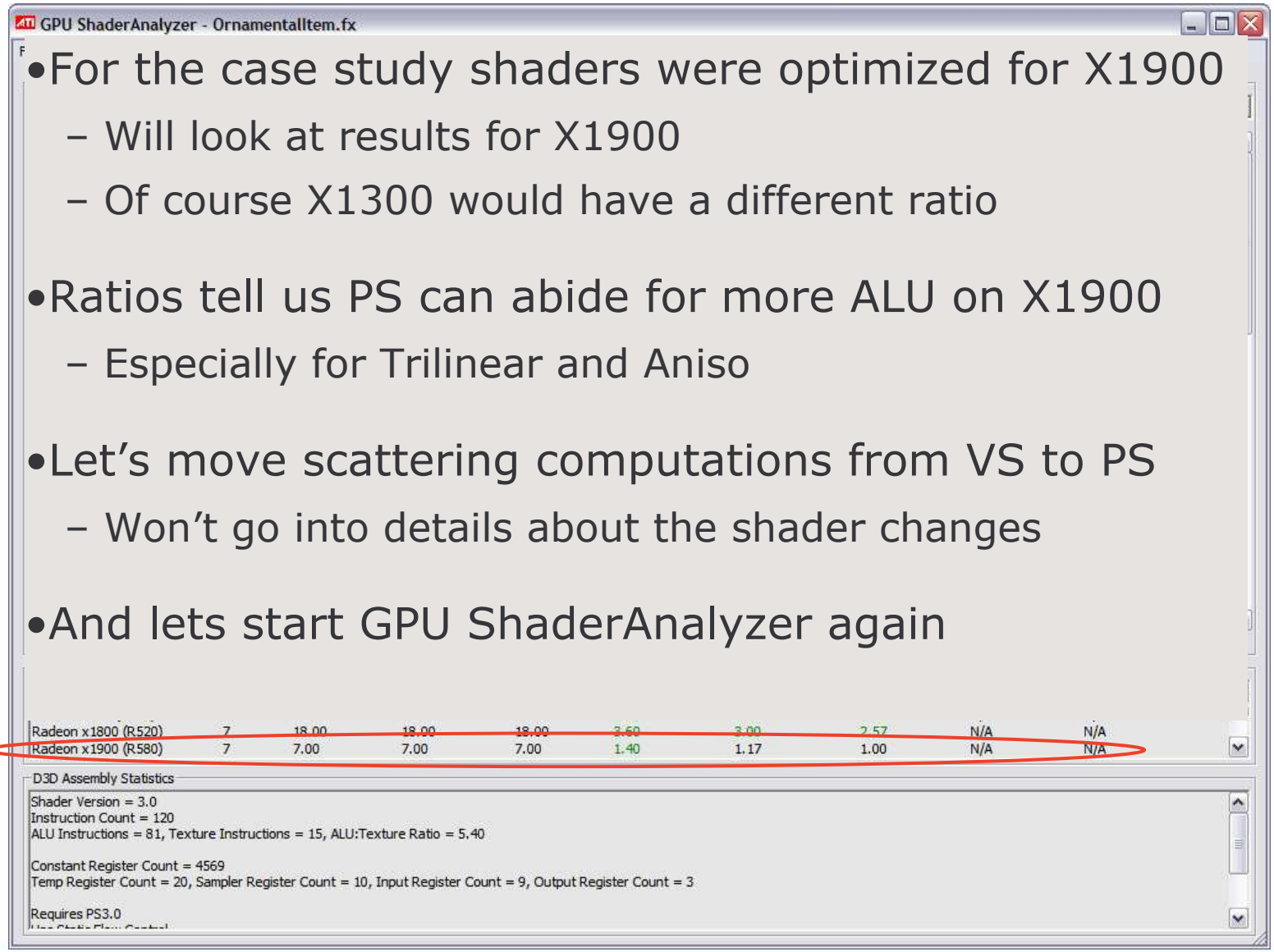
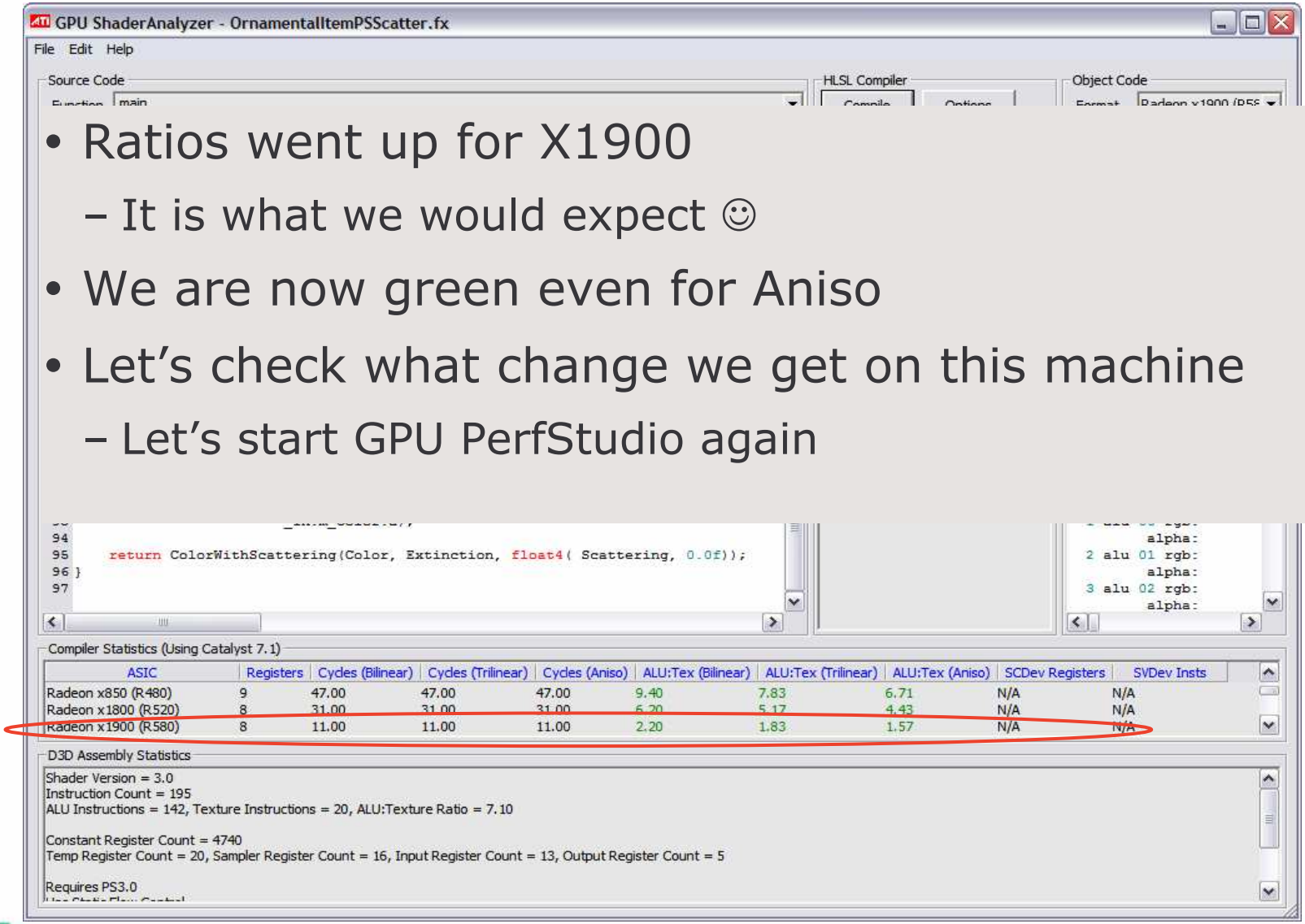
- We could move ALU load from VS to PS
  - This is no general advice!
  - only makes sense in this context on this constant target machine
    - With this fixed window resolution etc.
  - Other machines may behave differently
  - Different rules may apply for DX10 or unified shader HW!
- Let's first assess the current pixel shader
- Let's start GPU ShaderAnalyser

Running GPU ShaderAnalyzer

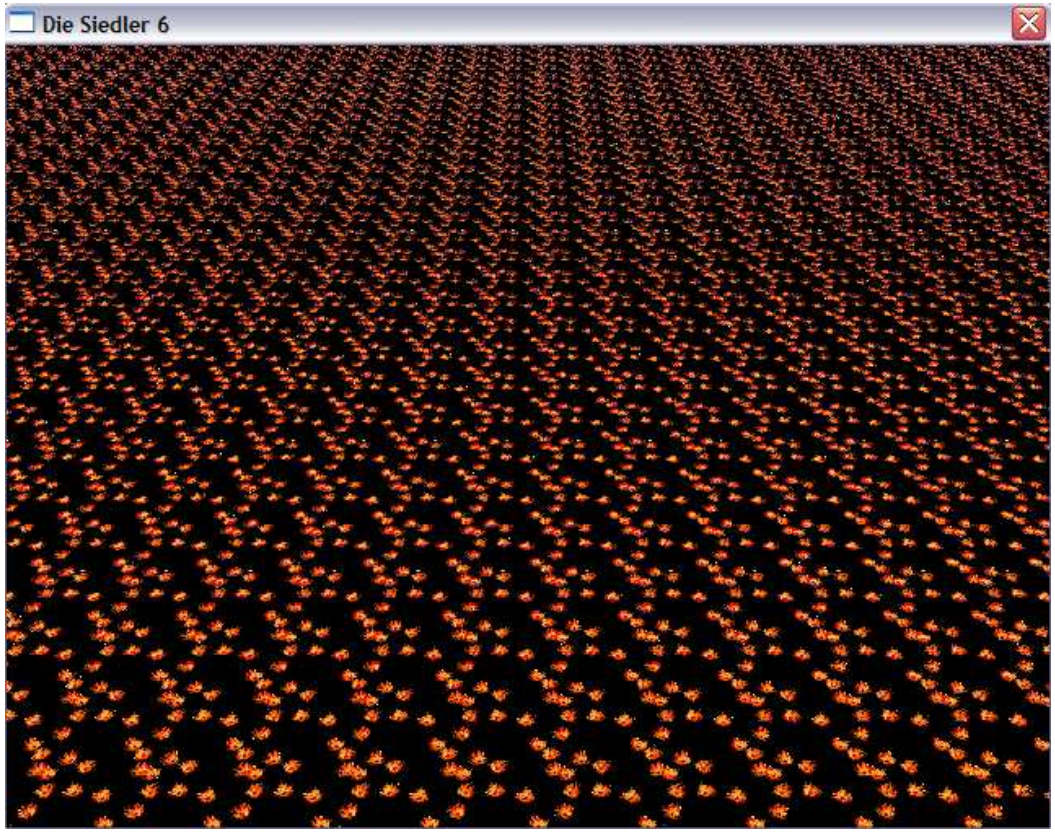


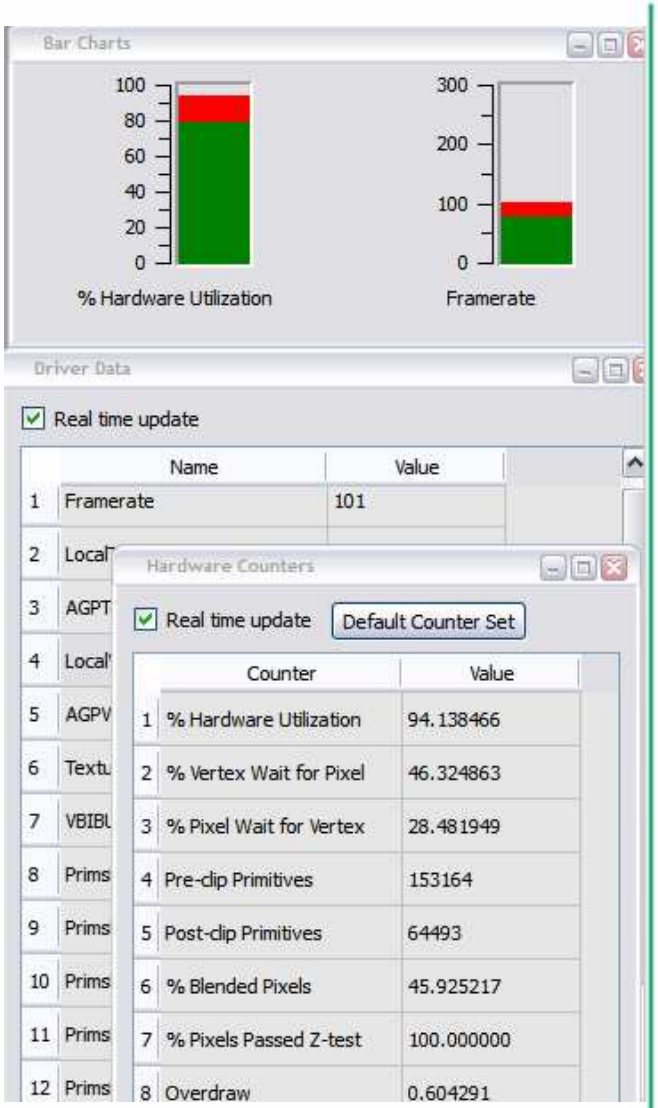
Reassessing the situation



- Ratios went up for X1900
  - It is what we would expect ☺
- We are now green even for Aniso
- Let's check what change we get on this machine
  - Let's start GPU PerfStudio again

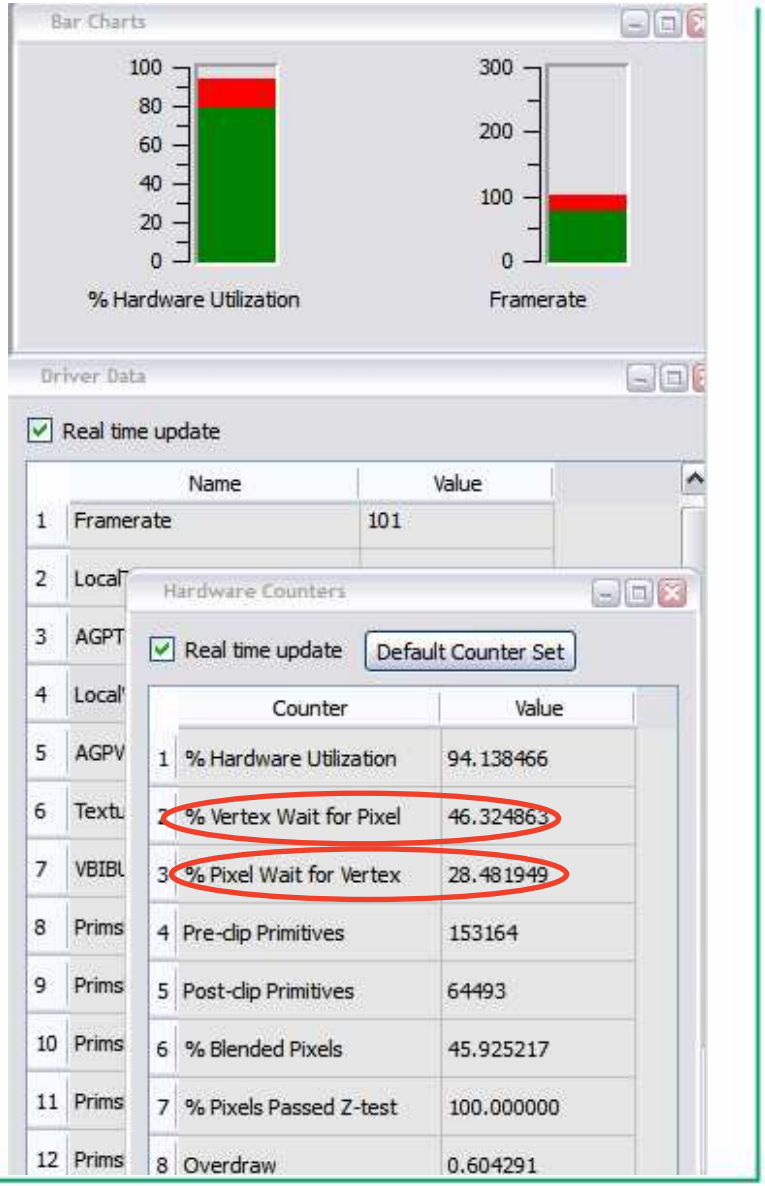
Let's run GPU PerfStudio again …





Observation & Results

- Reversed Pixel vs. Vertex
  - We're pixel limited now
- This is not necessarily a problem
  - It is hard to get balance
- FPS has increased
  - Now ~100 FPS
- We did the right thing ☺
  - At least on this machine
  - And this window resolution



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Conclusions & Call to action

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- AMD GPU tools are extremely valuable tools
  - They allow you to look inside the GPU
  - Find reasons for performance bottlenecks
  - Help to remove performance bottlenecks
- AMD GPU tools are free
- Try them as soon as possible
- Start to understand your GPU ☺

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Q&A

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